A Novel Instrument and Methodology for the In-Situ Measurement of the Stress in Thin Films

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We introduce a novel methodology for the in-situ measurement of mechanical stress during thin film growth utilizing a highly sensitive non-contact variation of the classic spherometer. By exploiting the known spherical deformation of the substrate the value of the stress induced curvature is inferred by measurement of only one point on the substrate's surface—the sagittal. From the known curvature the stress can be calculated using the well-known Stoney equation. Based on this methodology, a stress sensor has been designed which is simple, highly sensitive, compact, and low cost. As a result of its compact nature, the sensor can be mounted in any orientation to accommodate a given deposition geometry without the need for extensive modification to an already existing deposition system.

The technique employs the use of a double side polished substrate that offers good specular reflectivity and is isotropic in its mechanical properties, such as <111> oriented crystalline silicon or amorphous soda lime glass, for example. The measurement of the displacement of the uncoated side during deposition is performed with a high resolution (i.e. 5nm), commercially available, inexpensive, fiber optic sensor which can be used in both high vacuum and high temperature environments (i.e. 10^{-7} Torr and 480^{o}C, respectively). A key attribute of this instrument lies in its potential to achieve sensitivity that rivals other measurement techniques such as the micro cantilever method but, due to the comparatively larger substrate area, offers a more robust and practical alternative for subsequent measurement of additional characteristics of the film that can might be correlated to film stress.

We present measurement results of nickel films deposited by magnetron sputtering which show good qualitative agreement to the know behavior of polycrystalline films previously reported by Hoffman.